2.3.9. Maximum Detection Range

2.3.9.1. Purpose

The purpose of this test is to determine the maximum detection range for a target with a radar cross section similar to a mission relatable target and to evaluate the impact of this detection range upon intercept tactics.

2.3.9.2. General

Maximum detection range is a major yardstick of radar performance since one of the uses of air-to-air radar is to extend the surveillance envelope of the airplane beyond the visible range. As outlined in the radar theory section, the maximum radar detection range is influenced by a large number of factors, including the radar cross section of the target. Since exhaustive tests of a number of targets is beyond the scope of this test technique, it is very important to choose a target similar in radar cross section to the threat aircraft. This allows us to make a qualitative assessment of the maximum detection range in a mission relatable environment and then to support that assessment with mission relatable empirical data.

For the purposes of this test, the maximum detection point will be defined as the range at which the radar declares a hit on the target (or the operator can resolve a target hit in the case of an analog system display) for 50% of the antenna scans. The 50%, 0.5 "blip/scan" or Probability of Detection (PD) 0.5 requirement eliminates the possibility of the maximum detection range being defined at a point where a few spurious hits at long range are achieved. These spurious hits can occur for a number of reasons including test day atmospherics (ducting) and multi-path reinforcements of the long range return signal. Maximum detection range is often different for targets above than below the test airplane altitude due to the effects of clutter. In most cases both situations are important and mission relatable and should be measured. In addition, more than one long range mode is sometimes available on the same radar such as when a long range, pulsed TWS mode is available with a long range, VS doppler mode. Both modes should be tested.

2.3.9.3. Instrumentation

Data cards and an optional voice recorder are required for this test.

2.3.9.4. Data Required

Record the meteorological conditions for the test (including the altitude of all visible moisture layers). Record the target type and external configuration. Record the radar mode and the range at which a blip/scan ratio of 0.5 is estimated. During mission relatable intercepts, record the effects that the maximum detection range have upon intercept tactics.

2.3.9.5. Procedure

Place the target airplane on the nose at a range beyond the maximum displayable range of the radar (it is often possible to use a shorter range in cases where the radar has been flown before and rough maximum range data is available). The target should be on a reciprocal heading and 1,000 feet above the test airplane. Use a search mode, a medium to narrow azimuth scan limit and a single bar pattern. Perform the test with the TACAN in the air-to-air mode to determine target range. Compare the radar display with the TACAN range to the target, estimating when the blip/scan ratio is approximately 0.5. Record the range when the blip/scan ratio reaches 0.5. Repeat for any other long range search modes (usually includes a pulse or pulse doppler and a pure doppler VS mode). Descend the target to a low altitude, usually 500 feet Above Ground Level (AGL) is low enough while not compromising safety and repeat the test to determine the effects of clutter. For pulse doppler modes, choose the target and test airplane airspeeds to stay well clear of closure rates that place the target in radar blind speeds. Blind speed are discussed in detail in section 2.3.15. Closure rates can be converted to indicated airspeeds using the set of equations in section 2.3.13. During mission relatable intercepts, note the effects that the detection ranges have upon intercept tactics.

2.3.9.6. Data Analysis and Presentation

Using the test radar frequency, target configuration and aspect (essentially nose-on with this technique) derive the radar cross section of the target. Cross section versus aspect plots for various frequency bands exist for virtually every military target. If the target cross section is not the same as the value to which the radar is being tested, adjust the maximum detection range using equation 10. In most cases this is not necessary since the radar performance specifications are often written to match the general cross section of the threat as well as the available target fleet.

$$R_{max\ adj} = R_{max\ test}\left(\frac{\sigma_{desired}}{\sigma_{test}}\right)^{\frac{1}{4}} \qquad (10)$$

Care should be taken in applying equation (10) to situations where the cross sections differ by much greater than an order of magnitude. Is should also be noted that the maximum detection range can sometimes vary greatly from one data point to the next. Usually, a statistically significant set of data points are required. Sample size selection depends mainly upon the variance of the measurements from one test to the next and is discussed in detail in references 43 and 72.

Relate the maximum detection ranges to the amount of time and airspace available to maneuver to optimize attack tactics and compare the maximum detection range to the maximum range of the weapons carried. Finally, compare the maximum detection range to the capabilities of the threat and the expected advantages in tactics for the aircraft with the longest radar detection range. Compare the ranges of the different modes in both the heavy clutter and non-clutter environment to ensure the modes designed for each environment are compatible with the mission of the airplane (VS will usually do much better in clutter than a pulse or even pulse doppler mode).

2.3.9.7. Data Cards

A sample data card is provided as card 13.

CARD NUMBER ___ TIME ____ PRIORITY L/M/H

AIR-TO-AIR MAXIMUM DETECTION RANGE

[POSITION THE TARGET ON THE NOSE AT ___ NM HEADING INBOUND AND 1,000 FEET ABOVE THE TEST AIRPLANE. SET UP IN SEARCH MODE, A MEDIUM OR NARROW SCAN ANGLE LIMIT, RANGE SCALE ADEQUATE TO COVER THE TARGET RANGE AND SINGLE BAR. SET UP THE AIR-TO-AIR TACAN. NOTE THE RANGE AT PD=0.5. REPEAT IN THE VS MODE. REPEAT WITH THE TARGET AT ___ FEET AGL.]

TARGET TYPE AND CONFIGURATION_____

_____

VISIBLE MOISTURE LAYERS, ALTITUDE AND TYPE _____

_____

MODE	TARGET ALT	RANGE PD=0.5	TACAN RANGE

[EVALUATE THE EFFECTS OF THE MAXIMUM DETECTION RANGES DURING MISSION RELATABLE INTERCEPTS.]

EFFECTS:

Card 13: Air-to-Air Maximum Detection Range Data Card